

We claim:

1. A process for partially oxidizing propene to acrylic acid in the gas phase under heterogeneous catalysis by conducting a starting reaction gas mixture 1 which comprises propene, molecular oxygen and at least one inert gas and contains the molecular oxygen and the propene in a molar  $O_2 : C_3H_6$  ratio of  $\geq 1$  in a first reaction stage over a fixed catalyst bed 1 which is arranged in two spatially successive reaction zones A, B, the temperature of reaction zone A being a temperature in the range from 290 to 380°C and the temperature of reaction zone B likewise being a temperature in the range from 290 to 380°C, and whose active composition is at least one multimetal oxide comprising the elements Mo, Fe and Bi, in such a way that reaction zone A extends to a propene conversion of from 40 to 80 mol% and the propene conversion on single pass through the fixed catalyst bed 1 is  $\geq 90$  mol% and the accompanying selectivity of acrolein formation and also of acrylic acid by-production taken together is  $\geq 90$  mol%, the temperature of the product gas mixture leaving the first reaction stage is optionally reduced by cooling and molecular oxygen and/or inert gas are optionally added to the product gas mixture, and then the product gas mixture, as a starting reaction gas mixture 2 comprising acrolein, molecular oxygen and at least one inert gas and containing the molecular oxygen and the acrolein in a molar  $O_2 : C_3H_4O$  ratio of  $\geq 0.5$ , is conducted in a second reaction stage over a fixed catalyst bed 2 which is arranged in two spatially successive reaction zones C, D, the temperature of reaction zone C being a temperature in the range from 230 to 320°C and the temperature of reaction zone D likewise being a temperature in the range from 230 to 320°C, and whose active composition is at least one multimetal oxide comprising the elements Mo and V, in such a way that reaction zone C extends to an acrolein conversion of from 45 to 85 mol% and the acrolein conversion on single pass through the fixed catalyst bed 2 is  $\geq 90$  mol% and the selectivity of acrylic acid formation assessed over all reaction zones, based on converted propene, is  $\geq 80$  mol%, the sequence in time in which the reaction gas mixture flows through the reaction zones corresponding to the alphabetic sequence of the reaction zones, wherein
  - a) the hourly space velocity of the propene contained in the starting reaction gas mixture 1 on the fixed catalyst bed 1 is  $< 160$  l (STP) of propene/l of fixed catalyst bed 1  $\cdot$  h and  $\geq 90$  l (STP) of propene/l of fixed catalyst bed 1  $\cdot$  h;

- b) the volume-specific activity of the fixed catalyst bed 1 is either constant or increases at least once in the flow direction of the reaction gas mixture over the fixed catalyst bed 1;
- 5 c) the difference  $T^{\max A} - T^{\max B}$ , formed from the highest temperature  $T^{\max A}$  which the reaction gas mixture has within reaction zone A and the highest temperature  $T^{\max B}$  which the reaction gas mixture has within reaction zone B, is  $\geq 0^{\circ}\text{C}$ ;
- 10 d) the hourly space velocity of the acrolein contained in the starting reaction gas mixture 2 on the fixed catalyst bed 2 is  $\leq 145 \text{ l (STP) of acrolein/l of fixed catalyst bed 2} \cdot \text{h}$  and  $\geq 70 \text{ l (STP) of acrolein/l of fixed catalyst bed 2} \cdot \text{h}$ ;
- 15 e) the volume-specific activity of the fixed catalyst bed 2 increases at least once in the flow direction of the reaction gas mixture over the fixed catalyst bed 2; and
- 20 f) the difference  $T^{\max C} - T^{\max D}$ , formed from the highest temperature  $T^{\max C}$  which the reaction gas mixture has within reaction zone C and the highest temperature  $T^{\max D}$  which the reaction gas mixture has within reaction zone D, is  $\geq 0^{\circ}\text{C}$ .
- 25 2. A process as claimed in claim 1, wherein the difference  $T^{\max A} - T^{\max B}$  is  $\geq 3^{\circ}\text{C}$  and  $\leq 70^{\circ}\text{C}$ .
- 3. A process as claimed in claim 1, wherein the difference  $T^{\max A} - T^{\max B}$  is  $\geq 20^{\circ}\text{C}$  and  $\leq 60^{\circ}\text{C}$ .
- 30 4. A process as claimed in any of claims 1 to 3, wherein the difference  $T^{\max C} - T^{\max D}$  is  $\geq 3^{\circ}\text{C}$  and  $\leq 60^{\circ}\text{C}$ .
- 5. A process as claimed in any of claims 1 to 3, wherein the difference  $T^{\max C} - T^{\max D}$  is  $\geq 5^{\circ}\text{C}$  and  $\leq 40^{\circ}\text{C}$ .
- 35 6. A process as claimed in any of claims 1 to 5, wherein the hourly space velocity of the propene contained in the starting reaction gas mixture on the fixed catalyst bed 1 is  $\geq 100 \text{ l (STP) of propene/l} \cdot \text{h}$  and  $\leq 150 \text{ l (STP) of propene/l} \cdot \text{h}$ .

7. A process as claimed in any of claims 1 to 5, wherein the hourly space velocity of the propene contained in the starting reaction gas mixture on the fixed catalyst bed 1 is  $\geq 110$  l (STP) of propene/l  $\cdot$  h and  $\leq 145$  l (STP) of propene/l  $\cdot$  h.

5 8. A process as claimed in any of claims 1 to 7, wherein the difference  $T_B - T_A$  between the temperature of reaction zone B,  $T_B$ , and the temperature of reaction zone A,  $T_A$ , is  $\geq -10^\circ\text{C}$  and  $\leq 0^\circ\text{C}$ .

10 9. A process as claimed in any of claims 1 to 8, wherein the difference  $T_C - T_D$  between the temperature of reaction zone D,  $T_D$ , and the temperature of reaction zone C,  $T_C$ , is  $\geq -10^\circ\text{C}$  and  $\leq 0^\circ\text{C}$ .

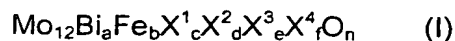
15 10. A process as claimed in any of claims 1 to 9, wherein the temperature of reaction zone A is from  $305$  to  $365^\circ\text{C}$ .

11. A process as claimed in any of claims 1 to 9, wherein the temperature of reaction zone A is from  $310$  to  $340^\circ\text{C}$ .

20 12. A process as claimed in any of claims 1 to 11, wherein the temperature of reaction zone C is from  $250$  to  $300^\circ\text{C}$ .

13. A process as claimed in any of claims 1 to 12, wherein the temperature of reaction zone C is from  $260$  to  $280^\circ\text{C}$ .

25 14. A process as claimed in any of claims 1 to 13, wherein the active composition of the fixed catalyst bed 1 is at least one multimetal oxide active composition of the general formula I



30

where

$\text{X}^1$  = nickel and/or cobalt,

$\text{X}^2$  = thallium, an alkali metal and/or an alkaline earth metal,

35  $\text{X}^3$  = zinc, phosphorus, arsenic, boron, antimony, tin, cerium, lead and/or tungsten,

$\text{X}^4$  = silicon, aluminum, titanium and/or zirconium,

$a$  = from  $0.5$  to  $5$ ,

40  $b$  = from  $0.01$  to  $5$ ,

c = from 0 to 10,

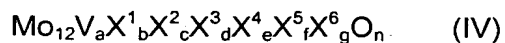
d = from 0 to 2,

e = from 0 to 8,

f = from 0 to 10 and

5 n = a number which is determined by the valency and frequency of the elements other than oxygen in I.

10 15. A process as claimed in any of claims 1 to 14, wherein the active composition of the fixed catalyst bed 2 is at least one multimetal oxide active composition of the general formula IV



where the variables are defined as follows:

15

$\text{X}^1 =$  W, Nb, Ta, Cr and/or Ce,

$\text{X}^2 =$  Cu, Ni, Co, Fe, Mn and/or Zn,

$\text{X}^3 =$  Sb and/or Bi,

$\text{X}^4 =$  one or more alkali metals,

20  $\text{X}^5 =$  one or more alkaline earth metals,

$\text{X}^6 =$  Si, Al, Ti and/or Zr,

a = from 1 to 6,

b = from 0.2 to 4,

25 c = from 0.5 to 18,

d = from 0 to 40,

e = from 0 to 2,

f = from 0 to 4,

g = from 0 to 40 and

30 n = a number which is determined by the valency and frequency of the elements other than oxygen in IV.